کارگاه یکروزه

Time Series Analysis Approaches to Decoding Neural Function at High Spatiotemporal Resolutions

بهتاش بابادی

دانشگاه مریلند

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Converging lines of evidence in theoretical and experimental neuroscience suggest that brain activity is a high-dimensional distributed spatiotemporal process emerging from underlying dynamic sparse structures. In these lecture series, we will explore how in various scenarios of interest the hypotheses of dynamicity and sparsity can be exploited in order to develop new time-series analysis methods to address several outstanding challenges faced by existing neural signal processing techniques.

In **part one**, we will give an overview of adaptive sparse system identification and present its applications in MEG source localization, spectrotemporal analysis of EEG and spiking data, and dynamic decoding of auditory attentional modulation from MEG. Apart from their theoretical significance, these results may bring new insights into sophisticated functional processes of the brain such as auditory processing and loss and recovery of consciousness under general anesthesia.

In **part two**, we will give an overview of compressed sensing theory and present new results on robust estimation of compressible point process models. In particular, we will analyze two classes of estimators for these models: regularized maximum likelihood and greedy algorithms. We will present theoretical guarantees that extend those of compressed sensing theory and characterize fundamental trade-offs between the number of measurements, model compressibility, and estimation error of point processes. We will further present applications to real data from neuronal activity in mouse’s lateral geniculate nucleus and ferret’s primary auditory cortex (A1) and retinal ganglion cells, which agree with our theoretical predictions.

In **part three**, we consider the problem of inferring functional circuitry of multiple cortical areas from spike recordings and two-photon imaging data. We develop new filtering and smoothing algorithms for estimating the parameters of a state-space model accounting for the Granger causality among the neurons in the ensemble with high temporal resolution. Application of the proposed algorithms to simultaneous multi-unit recordings from the ferret’s A1 and prefrontal (PFC) cortices under behavioral auditory tasks and spontaneous two-photon recordings from the mouse’s auditory cortex reveals the temporal details of the functional interaction between A1 and PFC under attentive behavior as well as among the A1 neurons under spontaneous activity, respectively, at unprecedented spatiotemporal resolutions.

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